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ABSTRACT

Described is the development of a science curriculum used with approximately 275 educable mentally handicapped children between the ages of 5 and 21 years. The curriculum is explained to have as goals the improvement of logical thinking with an emphasis on child centered activities. A summer workshop is explained to have resulted in the review of various contemporary science programs as they contribute to the development of scientific processes such as observing, classifying, and communicating. Stressed are the importance of staff planning, the selection of scientific processes to emphasize, the selection of a subject area of concentration, listing of available instructional materials, actual teaching, and final evaluation. A sample unit is given for the lower primary, upper primary, intermediate, and junior high levels. Evaluated are 30 units from the Elementary Science Study curriculum. Reaction to the new science program from advisory committee members, students, and staff is reported to be highly positive. (DB)

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A SCIENCE PROGRAM FOR CHILDREN WITH EXCEPTIONAL NEEDS

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Background — Riverview School

Riverview School is a central facility providing educational services for approximately 360 mentally handicapped children. The school, with its open concept design and multi-unit approach, provides educational services to a population of 20,000 students in grades K-12 from five participating school districts in Manitowoc County, Wisconsin. The school population includes children from ages 4 to 21 with approximately 275 educable mentally handicapped children and 85 trainable (transitional) mentally handicapped children. These children are assigned to one of five large open areas which are referred to as pods.

The educable children have been referred to Riverview School from regular education classes in one of the five participating school districts. Therefore, they arrive at varying chronoligical ages and with differing curricula backgrounds. The majority of these students will be transferred to special education programs at the secondary level in one of the three area high schools.

Other students may be mainstreamed back to regular education classes at various chronological ages. Those students not mainstreamed to regular classes or transferred to secondary special education programs will remain at Riverview School until age 21. These students will be in a transitional program that stresses career preparation.

Science Proposal

In April of 1972, a science proposal was funded under Title VI-B of the Elementary and Secondary Education Act to develop a science curriculum for educable mentally handicapped children attending Riverview School. The science curriculum was to provide the following:

1. A systematic approach to logical thinking for EMH children.
2. Child-centered activities emphasizing direct experiences.
3. Opportunities for EMH children to realize their natural surroundings to better succeed in all aspects of life related to earning a living.
4. An opportunity for a critical review and analysis of available instructional materials.

This curriculum was to be field tested and evaluated throughout the 1972-73 school year and then be published for dissemination to EMH educators in the state of Wisconsin.

Summer Workshop

During the summer of 1972 a four-week workshop was held at the school to work on the science program. The five participants

in the workshop were the lower primary, upper primary, intermediate, junior high and transitional pod unit leaders. The participants reviewed the philosophy of Riverview School which states that the mentally handicapped individual, like his more able peers, is an integral part of society and therefore, his education should discover and develop those abilities which will insure his worthy contribution and membership in that society. Permeating this philosophy are the fundamental purposes of education for all children: self realization; human relationships; and economic and civic responsibility. The science program was designed to reflect this over-all philosophy. It is concerned with helping the child become interested in and aware of the immediate world in which he lives; to relate to it; and to become better adjusted in it.

The different types of approaches and materials to be used in teaching science were to be reviewed with this philosophy in mind. Programs using textbooks series had been ruled out because of the reading problems that would be encountered by a majority of the students.

The contemporary science programs such as the American Association for Advancement of Science (AAAS) "Science--A Process Approach," the Science Curriculum Improvement Study (SCIS), the Elementary Science Study (ESS), and the Biological Science Curriculum Study (BSCS), "Me Now," were to be reviewed for their appropriateness for use with EMH children. For the most part,

these programs provide activity-centered units, some of which require little if any reading, and the materials appear to be adaptable for educable children.

It was noted in the literature and in discussions with other teachers that many students were unable to use scientific methods to attack new problems. Students appeared to be more capable of reciting exact facts and answers. Therefore, it seemed that more attention should be directed toward the processes of seeking answers rather than overemphasizing the finding of exact answers that would probably soon be forgotten. This would apply to problems that arise in all aspects of daily living for educable youngsters and adults.

With this in mind, it was believed that the science program for the mentally handicapped child should be organized and taught with the awareness of his particular need to develop independent thinking skills. It was also believed that the processes involved in scientific learning tend to promote the types of thinking that the child should have at his command. These science processes and their inter-relationship to all other areas of the curriculum will help to better prepare the student vocationally.

The concepts to be used throughout the program were to be those which are pertinent to the persisting life needs of the child. These concepts were to be taught parallel with, but secondary to, the processes of science in an activity-centered curriculum.

The following is a list of seven processes[1] that the workshop

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[1]Detailed description found in appendix on pages 30-32.

committee selected from "A Guide to Science Curriculum Development"[2] to be emphasized when teaching science units:

1. Observing: Power to see and note for some special purpose.
2. Classifying: Arrange in groups according to a selected system.
3. Communicating: Transferring information by writing, talking, etc.
4. Inferring: Drawing a conclusion based on observation requiring evaluation and judgement.
5. Measuring: Determining the extent, size, and quantity, capacity, etc., of something stressing the value of accuracy.
6. Predicting: Stating the expected result based on past experience.
7. Interpreting: The explanation of gathered information.

In an activity-centered approach which emphasizes direct experiences, the child should have the opportunity for socialization, discussion, and the experimentation of ideas with his peers. As the child's language evolves, he will be able to participate in discussions and more effectively offer his own ideas and observations. Such experiences broaden and improve the child's self-concept. Combining experience, knowledge and use of processes of science with this new sense of self will further assist the child adjusting to his environment.

The child should be encouraged to investigate, discuss and ask questions. Therefore, the role of the teacher is that of a guide. The teacher needs to organize and lead the child to see

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[2]A Guide to Science Curriculum Development, Wisconsin Department of Public Instruction, Bulletin No. 161.

the relationships of his findings to practical application in science and in persisting life situations. As the child becomes more actively involved in the investigation of science processes, he will move about, talk to his partner and most usually become excited about new discoveries. This is not to suggest chaos. The teacher is expected to have control at all times so that each student has the opportunity to benefit from the activity. It is most important that activities be planned that will permit direct student participation in the daily lessons.

The content which is used to develop scientific processes may occur at all levels. When varied, this content will spiral into all succeeding levels with wider, more meaningful application and a fresh outlook as opposed to mere dull repetition of concepts presented at earlier levels. The learnings should be structured so that they will relate to the total curriculum and be geared to the child's interest and future needs.

Four broad areas of selected study have been developed into units of work stressing the science processes. These areas include: biological science, physical science, earth science and general skills.[3] Ecology is an important phase of science and should be emphasized throughout the entire science program.

A Science Instructional Materials Bibliography has also been developed by the summer workshop participants. The bibliography lists all the science materials available at Riverview School including new materials purchased under the science grant.

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[3]Detailed description found in appendix on pages 33-37.

The 65-page bibliography is divided into 14 sub-headings: kits, film loops, tapes, transparencies, spirit masters, flannel board materials, slides, records, teaching pictures, charts, study prints, books, filmstrips and miscellaneous. Each of the materials under a sub-heading, except miscellaneous, is listed according to an appropriate area of study and level. The areas of study include biological science, physical science, earth science, and general skills. The four levels are lower primary (I), upper primary (II), intermediate (III) and junior high (IV).

This bibliography is available from Riverview School for $1.00 per copy. Note that the science material listed in the bibliography represents only a small sample of the many science materials available. It is also pointed out that the science materials are not evaluated in the bibliography. The materials purchased under the science grant and field tested during the 1972-73 school year are evaluated in this program description.

Staff Planning

Various approaches may be used in the teaching of science units. Some approaches are more structured, but all involve child-centered activities. The number of teaching stations, number of children in a group and rotation to the stations vary with the different units taught. In some instances a single kit is selected and used by all teachers within the pod. At other times two or more related kits will be used in the teaching of a unit. The children in all pods are heterogeniously grouped with the desire that the slow ones will be helped by and learn from the faster children. In the implementation and teaching of each unit much flexibility is needed. An idea or approach sometimes has to be "scrapped" and a new one tried.

It was found that a great deal of time will be spent in planning. This time should involve group planning by the five teachers in the pod as well as individual planning. During some units four teachers will teach the unit and the fifth will be

free to help gather daily materials or to do advance planning for the next unit. Most units, however, involve all five teachers planning and teaching the entire unit. It should be emphasized that teacher creativity and initiative is an important aspect to the success of the units. Teachers with a more traditional background may find it necessary to adapt their teaching style and approach toward stressing child-centered activities.

The first step in planning involves the selection of the area(s) of study. Generally, only one broad area of study is recommended for use at a given time. However, it has been found that some of the general skills units work well with any of the other three major areas. Therefore, biological science, physical science, or earth science would be selected singularly or combined with general skills.

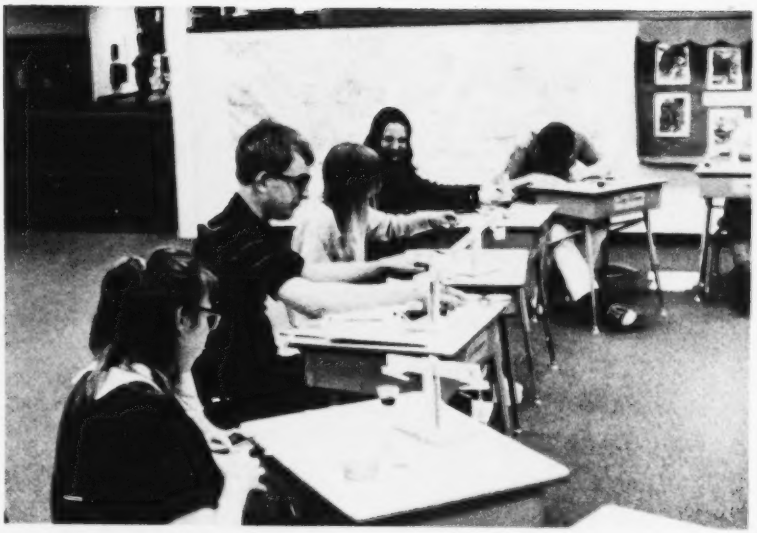
It is nearly impossible to select only one or two processes to be developed without covering any other process. It is possible, however, to decide ahead of time which processes should be stressed. This is primarily based on the age of the children and their past experiences with processes, and also partially determined by the materials to be used. With younger children the processes to be stressed will generally include observing, classifying, and communicating, while older children are to be encouraged to develop processes of measuring, predicting and interpreting. Remember that it is possible to deal with all the processes in a given unit of work, but only pre-determined processes should be stressed.

In the second major step of planning, the area of study will be broken down to more specific areas of concentration. Biological science may be broken down to the study of plants or more specifically, the growing of plants. The processes to be stressed should now be firmly in mind as should ways to develop these processes. If observation is a main process and the growing of plants is the major activity, then questions and problems should be developed. Do some plants grow faster? What effects does the sun, water, soil, etc., have on plant growth? Note that the teacher is not telling, but rather asking and guiding the children.

In the third step a listing of available material for that area of study and age group should be compiled and previewed for possible use. An attempt should be made to find materials that will interest children by letting them become actively involved. Films, filmstrips, worksheets, etc. for the unit are generally better used as reinforcement activities rather than core materials.

Step four will vary according to the number of teachers involved. If more than one teacher is involved it will be necessary to decide what each teacher will be responsible for and how the children will be grouped.

In step five the teacher(s) will need to be flexible and alert to possible daily changes in the plans. Children's interest can change rapidly and, therefore, should be gauged closely. The motivation and interest of the children will probably be the best measure of the daily success of the unit.



Finally, an evaluation should be made to record individual involvement and progress as well as the success of the total unit. The individual record sheet developed for Riverview children provides space for indicating the area(s) of study, the processes stressed and general comments.

In summary, the following is a brief outline of the steps used in the development of a unit:

I. Decide on Unit
   - A. Broad area of study
   - B. Processes

II. Ideas to Develop
   - A. Objectives
   - B. Processes (specific)
   - C. Problems to be solved by students

III. Materials Available
   - A. Kits
   - B. Guides
   - C. Filmstrips and filmloops
   - D. General Science Equipment

IV. Divide the Unit into Sub-Units
   - A. Areas chosen by various teachers
   - B. Further research
   - C. Further development of processes
   - D. Gather appropriate materials
   - E. Divide students
     1. Groupings
     2. Teaching Station
     3. Type of Rotation
     4. Approximate time to be spent on unit

V. Actual Teaching

A. Flexibility in daily Planning

B. Flexibility in daily evaluation

VI. Final Evaluation

A. Fill out student record sheets

B. Success of unit

On the following pages are some sample plans for a unit on plants. In addition to the processes stressed, the materials used and some possible activities are also listed. A sample student record sheet for indicating student progress for the year is illustrated on page 18.

UNIT: (A) Biological Science - Plants LEVEL: Lower Primary
DATE: 1972-73

Processes	Activities	Materials
Observe Classify Communicate Measure	A. Have students plant and grow various types of seeds. 1. Compare seeds and how they are to be planted. 2. Compare effects of sun, water, soil, etc., on plant growth. 3. Compare similarities and differences of plants. 4. Do plants have the same parts: Flower, fruit, leaves, stems? 5. Do some plants grow faster? Measure growth. 6. Do all plants start to grow at the same time. 7. How do the seeds develop. 8. Using different kinds of soil, do all plants grow the same?	ESS Kits: Growing Seeds Match and Measure Various types of soils: sand, clay, gravel, etc.

UNIT: (A) Biological Science - Plants LEVEL: Lower Primary
DATE: 1972-73

Processes	Activities	Materials
	9. Place plants in various parts of the room. Where do they grow best?	
Observe Communicate Classify	A. Watch and discuss filmstrip. B. Comparison of seeds. 1. Do all seeds look the same? 2. Are they covered the same? (Hard - soft)? 3. Are all small things seeds?	Filmstrip: "Story of Seeds" Various types of seeds and other small items to compare to seeds
Observe Classify Communicate	A. Visit a farm. 1. What are the different types of plants? 2. How are they cared for? Is anything added to the soil? 3. Do all plants grow the same? Above ground? On trees?	

UNIT: (A) Biological Science - Plants LEVEL: Upper Primary
DATE: 1972-73

Processes	Activities	Materials
Observe Communicate Classify	Have children arrange seeds according to size, shape, color, etc. and make a chart showing how they arranged them.	Variety of seeds Construction paper Glue
Observe Classify Communicate Infer	Have children plant seeds and: 1. Watch how the different seeds sprout. 2. Record daily growth on a chart using either a ruler or paper strips. 3. Observe what happens when: a. a plant is placed in the dark. b. a plant is not given water. c. a plant gets light on only one side. d. a jar is placed over a plant.	ESS Kits Growing Seeds Starting from Seeds Life of Beans and Peas Resource Book: A Child's Garden Seeds Rulers Paper Containers
Observe Communicate	Have children plant seeds in root boxes and observe growth.	Root boxes Seeds--radish, beans
Observe Communicate	Have children observe film loop in small group and discuss.	Film loop: "Bean Sprouts"

UNIT: (A) Biological Science - Plants LEVEL: Intermediate
DATE: 1972-73

Processes	Activities	Materials
Communicate Classify Observe Measure Infer	Have student make a "tumbler garden." The student plants a variety of seeds. 1. Label plant area for proper plant identification. 2. Observe how different seeds sprout. 3. Chart daily growth on a bar graph. 4. Observe what happens when some plants are covered with black paper. (cellophane paper) 5. Observe what happens when some plants aren't watered.	ESS Kit Starting from Seeds Large glass Variety of seeds Bar graph Sheets of black paper Sheets of plastic
Communicate Observe	Observe filmstrip on plant growth.	Filmstrip: "Plants"
Observe Communicate	Student visits a truck garden to see final growth of vegetables followed by a trip to a local cannery.	

UNIT: (A) Biological Science - Plants LEVEL: Junior High
DATE: 1972-73

Processes	Activities	Materials
Observe Predict	Have students experiment with growing various molds. Examine portions of the mold under magnifying glasses and microscopes.	Microgardening ESS Kit 22 Microscopes Slides Magnifying Glasses
Observe Measure Predict	Plant a variety of seeds and perform individual experiments, keeping daily records.	ESS Kit 35 Starting from Seeds
Classify Communicate	Listen to tape, discuss in group setting. Complete worksheets.	Tape 34 Seedless Plants
Communicate	View and discuss questions in small groups.	Transparency 24 Plant Structure Part 1

Science Record Sheet

The science record sheet should be provided for every child in the class. It is designed to be a brief and concise record of what the individual child participates in during the school year. It also provides an indication of the processes stressed and progress made as determined by the teacher. In the sample record sheet a level has not been indicated and it should be pointed out that many of the units listed could be used with modification at any level. If the general skills area, with the match and measure unit, is developed for the upper primary level, the processes to stress might be observing, classifying and communicating, while at the junior high level the processes to stress for the same unit might be measuring and predicting. Again, this must be determined by the teacher according to the needs of the individual child.

The individual record sheets should be given to the child's succeeding teachers.

Science Record Sheet — Sample

Name_____ Level_____
Year_____

1	Process emphasized
x	Progress Indicated

Areas
- A. Biological Science
- B. Physical Science
- C. Earth Science
- D. General Skills

Area	Unit	Observing	Classifying	Communicating	Inferring	Measuring	Predicting	Interpreting	Comments
D	Match and Measure	1/x	1/x	1/x	1/x	1/x	1/x	1/x	Participated well in all activities.
D	Tangrams	1/x	1/x	1/x	1/x	1/x	–	–	Worked independently very well.
A	Eggs and Tadpoles	1/x	–	1/x	1/x	–	1	–	Observed changes and recorded them in his booklet.
A	Changes	1/x	1/x	1/x	1	1/x	–	–	Was able to note changes and willing to discuss them.
C	Colored Solutions	1/x	1	1/x	1	–	–	–	Observed what happened with the colored solutions and was interested in unit.
A	Seeds and Plants	1/x	1	1/x	1	1/x	–	–	Had a difficult time in observing differences in seeds but enjoyed the planting, observing and measuring.
B	Simple Machines	1/x	1	1/x	1	1/x	1	–	Not too interested in this unit, did some observing and participated a little in discussion and measuring activities.

ESS Units

After a review of science materials, a number of Elementary Science Study (ESS) units were purchased from McGraw-Hill prior to the beginning of the school year. It was believed that this material would be the most adaptive in meeting the needs of the EMH child at Riverview School. Additional units and materials were purchased throughout the school year.

ESS units are designed to encourage the children to explore and do new things. The major objective is to help the child become acquainted with his environment and to develop an interest and ability to understand and relate to it. The child has the opportunity to use concrete objects in an activity-centered learning environment.

There is a total of 56 units or kits. The largest number of units are in physical science (21), then biological science (19), general skills (12) and earth science (4). The amount of material in a unit varies greatly from just a teacher's guide to several boxes of items. Likewise, the cost of the units varies from a few dollars to several hundred dollars, especially when filmloops are purchased to accompany a number of the units. It is found that no matter how much of the unit is purchased or what the cost involved is, the success of the unit depends largely on the creativity and initiative of the teacher in adapting the material to meet the needs of the children. For example, a unit on crayfish was used very successfully in the lower primary, upper primary and transitional areas, and the cost is approximately

$2.50 for the teacher's guide and 50¢ for each of 16 crayfish. This unit was excellent for developing the processes of observation and communication. The crayfish were kept in a small plastic swimming pool. This provided easy access for observation, handling and feeding. The students may be actively involved in a host of other activities such as recording and discussing behavior, building shelters or drawing pictures of the crayfish.

In making the original purchase of units, it was necessary to rely on comments of teachers in regular and special education who used the ESS units. A brief preview of available units was also helpful. As the school year progressed, additional units were purchased. For example, tangrams proved so successful that units were purchased for each of the five pods.

The following is a listing of the ESS units that were used during the 1972-73 school year. This listing also shows the levels at which each unit was used and a rating by the teachers. It should be noted that a number of factors were involved in the rating, primarily that of adaptability of material for that particular age level and the interest demonstrated by the children. Appendix 3, pages 38-40, is a listing of all 56 units showing those purchased.

Even though the project was aimed primarily at developing a science guide for educable children, the materials purchased were made available to the teachers of the transitional (trainable) children. With modification some of the kits proved useful in getting the children actively involved in science and in developing

science processes. The general skills units were particularly adaptive, expecially tangrams, geo blocks and pattern blocks. Other units used successfully included crayfish, clay boats, sink and float and growing seeds.

ESS Units Evaluation

ESS Units	Junior High C.A. 13-16	Intermediate C.A. 11-13	Upper Primary C.A. 8-11	Lower Primary C.A. 5-8
	A. Biological Science			
Brine Shrimp			Poor	
Changes			Fair	
Crayfish			Excellent	Excellent
Earthworms		Good		
Eggs & Tadpoles			Excellent	
Growing Seeds			Good	
Life of Beans & Peas			Good	
Pond Water		Good		
Small Things	Good			
Tracks		Excellent		

ESS Unit Evaluation

ESS Units	Junior High C.A. 13-16	Intermediate C.A. 11-13	Upper Primary C.A. 8-11	Lower Primary C.A. 5-8
	B. Physical Science			
Batteries & Bulbs	Good			
Clay Boats		Excellent		
Colored Solutions			Excellent	
Drops Streams & Containers		Good		
Ice Cubes			Poor	
Kitchen Physics		Good		
Mirror Cards				Good
Mobiles	Good			
Mystery Powders		Excellent	Good	

ESS Unit Evaluation

ESS Units	Junior High C.A. 13-16	Intermediate C.A. 11-13	Upper Primary C.A. 8-11	Lower Primary C.A. 5-8
	C. Earth Science			
Rocks & Charts	Good			
Sand		Excellent		
	D. General Skills			
Attribute Games & Problems	Fair			Fair
Geo Blocks		Good		Good
Match & Measure	Good		Excellent	
Musical Recipe Book		Fair		
Pattern Blocks				Fair
Peas & Particles	Excellent			
Primary Balancing				Excellent
Structures	Good	Good		
Tangrams	Excellent	Excellent	Excellent	Excellent

Science Materials (Other than ESS)

There appeared to be a lack of sufficient material in ESS for lower primary aged children and therefore other material was previewed. Several kits were purchased from the Science Curriculum Improvement Study (SCIS) to be used primarily with the younger child. These included: Kit I: Organisms, Kit II: Interaction and Systems, and Kit III: Material Objects. The teachers in the lower primary pod found these kits to be adaptable for use with the children in their pod.

The Biological Science Curriculum Study (BSCS) program, "Me Now," was briefly examined during the summer of 1972. At that time it was decided that the program did not provide the type of child-centered activities desired and that the cost (approximately $800 for a class of 30 students) was too expensive for purchasing without having more information about the program. This program had been successfully used with handicapped children in Columbus, Wisconsin, and was demonstrated at the National Science Teachers Association Convention in Detroit. After viewing these demonstrations, Riverview decided to purchase the program.

Evaluation and General Reactions

In the initial planning of the science program, a major concern was a method of evaluating the individual student progress in science. It was found that many of the general information questions in the Peabody Individual Achievement Test (PIAT) were related to science content. Since all Riverview children are tested twice each year with the PIAT, it was thought that these

related science questions, to show possible gains, might be isolated for study. The main problem with this method was that it would not show an accurate growth in the processes of science, but rather a recall of data. Therefore, throughout the year subjective evaluations of the teachers and the comments of parents, students and visitors were used for a rating of the program. Some of the comments made by the science advisory committee (comprised of three parents, two educators from staffs other than Riverview, and one Riverview staff member), the students and the teachers were:

ADVISORY COMMITTEE

"Students highly motivated by materials and questions presented by the teachers."

"Great deal of potential for vocational education enhancement from the methods being used to teach science."

"Amazed at the similarities of responses between the regular and special education students."

"Students were very interested in their work and behavior of students surprisingly good."

"Students were very well behaved even though they were working in many different areas of the pod."

"This is the way science should be--Fun!"

"Interaction of students seems to be helping the more withdrawn students become involved."

STUDENTS

"Are we going to have science today?"

"We do things we never did before."

"Science is fun because we do stuff with our hands."

"It's fun looking at things with a microscope."

"Now I have a hobby. I make things at home that we did in our science class."

"I decorate my bedroom with some of the things I made in science."

"Making a magic garden at school was fun. I brought the recipe home and made another one."

"I like to take long walks at home now because I see more things."

STAFF

"The new science program allows for much student creativity."

"Many units offer opportunities to measure and predict."

"A number of material modifications are necessary in the teaching of some science units."

"I received a phone call from a mother of one of my students. She wanted to know what science unit was to be taught next. After hearing the name of the unit whe said, 'Oh, goodness! There go my kitchen supplies,' intimating he would do a similar activity at home as we had done in school."

"The teacher manuals for the various units are helpful when planning activities for the students."

"Children seem to be more aware of things around them."

"I don't necessarily enjoy teaching science more this year than last year, but the students seem to be benefiting more from it."

It should be noted that while attending the National Science Teachers Association Convention in Detroit (April, 1973) a science test was found that stressed processes. It is included in the Comprehensive Tests of Basic Skills, Expanded Edition, Form S (CTBS/S)[4]. Apparently it is the first one available that emphasizes the measurement of skills or processes rather than the recall of data. The CTBS/S battery will be published for Fall, 1973, testing. As currently designed, the science test will be

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[4]To be published in September, 1973, by CTB/McGraw-Hill, Del Monte Research Park, Monterey, California 93940. Spans Grades 2-12 in five levels.

available only as a part of the complete battery. Therefore, anyone desiring to evaluate students in science would be required to purchase the entire battery.

Summary

The project has revealed that child-centered activities are successful with educable mentally handicapped children. The students have demonstrated a high degree of interest in science when they are permitted to be active participants.

It has been found that many of the Elementary Science Study Kits are adaptable for use with EMH children. A great deal depends on the innovativeness of individual teachers to use open ended materials like ESS. More time is required in modifying the ESS Kits for the younger EMH child, especially those in the 5-8 year old range.

The cost of ESS materials depends on the units selected and in many instances the teacher's manual alone is used to initiate

child-centered activities. Regardless of the ESS Kit and its cost, a certain degree of modification and teacher preparation is necessary to use the kits effectively with EMH children.

In addition to the ESS Kits, many other instructional materials (such as filmstrips, records, transparencies, worksheets, and books) were used successfully in the development of child-centered activities. Regardless of the material used, it was found that the teacher is the "key" to the success of an activity oriented science program for developing science process skills.

It is hoped that teachers in any of the exceptional areas will consider child-centered activities and process development for their children. As all children become more proficient in process skills, especially exceptional children, their chances for success in life will be greatly enhanced.

Appendix 1

Science Processes

Process: Observing

Observation is the act or power of seeing and noting for some special purpose. It can be made in a variety of ways using all the senses and is influenced by the experience of the observer. Observations are basic to the scientific approach to all questions at any age or level of experience.

Skill Sequence

A. Distinguishing differences in physical properties.

B. Manipulating or changing an object for observation.

C. Using instruments to aid the senses.

D. Identifying changes in properties and measuring rates of change.

E. Repeating observations to improve reliability.

Process: Classifying

The arrangement into classes or groups according to some system such as color, shape, size, etc. The systems are based on the observation of similarities and differences by an arbitrarily selected characteristic(s).

Skill Sequence

A. Perceiving similarities and differences in a set of objects.

B. Separating a set of objects into two groups according to those that have or do not have a single characteristic.

C. Grouping a set of objects on the basis of a gross characteristic, such as color or shape, where many identifiable variations are possible.

D. Different ways of classifying the same set of objects.

Process: Communicating

The transferring of information by talking, writing, etc., in order to communicate observations to others.

Note: Process sequence modified from "A Guide to Science Curriculum Development, Wisconsin Department of Public Instruction, Bulletin No. 161.

Skill Sequence

A. Describing observations verbally.

B. Describing conditions under which observations were made.

C. Recording observations in a systematic way.

D. Constructing tables and graphs to communicate data.

Process: Inferring

The act of drawing a conclusion based on observation using evaluation and judgement.

Skill Sequence

A. Demonstrating that inference is based upon observation.

B. Separating essential and non-essential observations.

C. Observing cause-and-effect relationships of related events.

D. Identifying limitations of inferences.

E. Developing plans to test the validity of inferences.

Process: Measuring

The act of determining the size, quantity, capacity, etc., of something especially by comparison with a standard unit.

Skill Sequence

A. Arranging objects in terms of selecting common property(s).

B. Comparing quantities such as length, area, volume and weight to arbitrary units.

C. Using standard units for measurement.

D. Measuring quantities which depend upon more than one variable.

E. Converting from one system of units to another.

F. Using and devising indirect means to measure quantities.

G. Using methods of estimation to measure quantities.

Process: Predicting

The stating of the expected result based on past experience. Prediction is based on inference and its reliability is determined by the accuracy of past observations.

Skill Sequence

A. Distinguishing between guessing and predicting.

B. Using repeated observations of an event to predict the next occurrence of that event.

C. Using a series of related observations to predict an unobserved event.

Process: Interpreting Data

The explanation of gathered information requiring the application of other basic process skills - inferring, predicting, classifying and communicating. Interpretations are not necessarily constant and are subject to revision based on new data.

Skill Sequence

A. Selecting data pertinent to the question asked.

B. Assessing the validity, precision and usefulness of the data.

C. Using the data to see relationships and trends.

D. Selecting the most acceptable interpretation of the data.

Appendix 2

Area of Study

A. Biological Science

1. People

a. Identification of:

(1) body parts

(2) senses

b. Function of:

(1) body parts

(2) senses

c. Identification of physical needs

(1) rest

(2) food-air-water

(3) shelter

d. Purposes of physical needs

(1) rest

(2) food-air-water

(3) shelter

(4) elimination

(5) reproduction

2. Animals

a. Identification of:

(1) pets

(2) domestic

(3) zoo

(4) water

(5) birds

(6) wild

(7) insects

b. Physical characteristics

c. Care

(1) food-air-water

(2) shelter

d. Habitat

e. Method of self preservation

(1) food-water

(2) shelter

(3) protection

(4) young

f. Contribution of domestic animals

(1) companionship

(2) guardianship

(3) work

(4) food

(5) clothing

(6) by-products

g. Contribution of wild animals

(1) food

(2) clothing

(3) by-products

(4) processed goods

h. Conservation of domestic and wild

(1) feeding

(2) protection

(3) laws

3. Plants

a. Identification of:

(1) trees

(2) flowers

(3) fruits

(4) vegetables

(5) shrubs

(6) grain

b. Classification of:

(1) trees

(2) flowers

(3) fruits

(4) vegetables

(5) shrubs

(6) grain

c. Identification and characteristics of plant parts

(1) leaves

(2) stems

(3) roots

(4) blossoms

(5) seeds

d. Growth needs

(1) soil

(2) air

(3) water

(4) sun

(5) reproduction

e. Benefits

(1) food

(2) clothing

(3) shelter

(4) decoration

(5) by-products

f. Conservation

B. Physical Science

1. Machines

a. Identification, function and operation

(1) hand tools

(a) home

(b) work

(c) recreation

(2) power driven

(a) home tools

(b) home equipment

(c) work tools

b. Relationship to:

(1) communication

(2) transportation

2. Sources of Energy and force

a. Identification of:

(1) sun

(2) wind

(3) fire

(4) heat and light

(5) muscle

(6) oil

(7) gas

(8) coal

b. Value and use of:

(1) sun

(2) sound

(3) heat and light

(4) steam as power

(5) muscle

(6) oil

(7) gas

(8) coal

(9) magnetic

(10) chemical

(11) atomic

c. Relationship to:

(1) work

(2) transportation

(3) communication

(4) recreation

(5) preservation of life

C. Earth Science

1. Seasons

a. Identification of:

(1) summer

(2) fall

(3) winter

(4) spring

b. Characteristics

(1) summer

(2) fall

(3) winter

(4) spring

2. Weather

a. Identification of Conditions

(1) fog

(2) ice

(3) snow

(4) rain

(5) wind

(6) clouds

(7) lightning

(8) thunder

(9) rainbow

b. Characteristics of:

(1) fog

(2) ice

(3) snow

(4) rain

(5) wind

(6) clouds

(7) lightning

(8) thunder

(9) rainbow

(10) frost

(11) hail

(12) storm

(13) mist

(14) humidity

(15) drought

c. Effect of weather on:

(1) manner of dress

(2) recreation

(3) health

(4) food supply

(5) work

(6) travel

(7) growth

(8) economy

d. Measurement and precautions

(1) temperature

(2) thermometer

(3) weather forecast

(4) ice

(5) snow

(6) storms

(7) fog

(8) wind

(9) rain

(10) frost

(11) tornado

3. Earth

a. Identification

(1) size

(2) age

(3) composition

(a) land

(b) water

(c) minerals

b. Characteristics

(1) size (large)

(2) age (old)

(3) composition

(a) land

(b) water

(c) minerals

(4) gravity

(5) movement

(6) magnetic forces

c. Conservation

4. Earth Neighbors

a. Identification of:

(1) sun

(2) moon

(3) stars

(4) planets

b. Effect upon the earth

(1) sun

(2) moon

D. General Skills

Appendix 3

ESS Units

ESS Units	Entire Kit Purchased	Only Printed Material Purchased	Manual Only Purchased	Film Loops Available	Film Loops Purchased**
Biological Science					
Animal Activity		x			
Animals in Classroom		x			
Behavior of Mealworms	x				
Bones			x	5	5
Brine Shrimp	x			2	2
Budding Twigs	x*				
Butterflies	x*			6	6
Changes	x*				
Crayfish	x*				
Earthworms	x				
Eggs and Tadpoles	x			8	5
Growing Seeds	x			2	2
Life of Beans & Peas	x*				
Microgardening	x			7	2
Mosquitoes	x*				
Pond Water	x				
Small Things	x			11	2
Starting From Seeds	x*				
Tracks	x			1	1

*Kit contains only a manual
**see page 41 for film loops purchased.

ESS Units	Entire Kit Purchased	Only Printed Material Purchased	Manual Only Purchased	Film Loops Available	Film Loops Purchased
Physical Science					
Balloons & Gases			x		
Batteries & Bulbs	x				
Batteries & Bulbs II	x*				
Clay Boats	x				
Colored Solutions	x				
Drops, Streams & Containers	x				
Games & Airs	x			4	4
Heating & Cooling		x			
Ice Cubes	x				
Kitchen Physics	x				
Lights & Shadows	x*			3	2
Mirro Cards	x				
Mobiles			x		
Mystery Powders	x				
Optics			x		
Pendulums			x	5	0
Senior Balancing			x		
Sink or Float	x				
Spinning Tables			x		
Stream Tables		x			
Water Flow			x		

ESS Units	Entire Kit Purchased	Only Printed Material Purchased	Manual Only Purchased	Film Loops Available	Film Loops Purchased
Earth Science					
Daytime Astronomy	x*				
Rocks & Charts	x				
Sand	x				
Where is the Moon	x				
General Skills					
Attribute Games & Problems	x				
Geo Blocks	x				
Mapping		x			
Match & Measure	x				
Musical Instrument Recipe Book	x*				
Pattern Blocks	x				
Peas & Particles	x				
Primary Balancing	x				
Printing	x				
Structures	x*				
Tangrams	x				
Whistles & Strings			x		

Film Loops - Purchased from ESS

Bones:	Head and Neck
	Shoulder
	Knee and Elbow
	Hand
	Foot
Brine Shrimp:	Brine Shrimp I
	Brine Shrimp II
Butterflies:	Black Swallowtail Butterfly: Egg Laying, Hatching & Larvae
	Black Swallowtail Butterfly: Larval Molt
	Black Swallowtail Butterfly: Preparing to Pupate (1)
	Black Swallowtail Butterfly: Preparing to Pupate (2)
	Black Swallowtail Butterfly: Pupal Molt
	Black Swallowtail Butterfly: Emergence
Eggs and Tadpoles:	Frog Egg I: First Cell Division to Early Neural Fold
	Frog Egg II: Development of the Body Regions
	Frogg Egg III: Continued Development to Hatching
	Tadpole I
	Tadpole II
Gases and "Airs":	Candle Burning I
	Candle Burning II
	Candle Burning Techniques
	The Mouse and the Candle

Growing Seeds:	Bean Sprouts
	Plant Growth--Graphing
Kitchen Physics:	Beading of a Water Column
	Water Rise in Blotter Strips of Graded width
	Water Rise in Blotter Strips exposed and Enclosed
Microgardening:	Rotting Pear
	Mushroom Growth and Reaction
Small Things:	Amoeba
	Budding of Yeast Cells
Tracks:	The Horse

Bibliography

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Biological Sciences Curriculum Study (BSCS) - "Me Now," P. O. Box 930, Boulder, Colorado 80302. Materials available from Hubbard Scientific Company, P. O. Box 105, Northbrook, Illinois 60062.

Elementary Science Study (ESS), 55 Chapel Street, Newton, Massachusetts 02160. Materials available from Webster Division, McGraw-Hill Book Company, Manchester Road, Manchester, Missouri 63011

Science Curriculum Improvement Study (SCIS), Lawrence Hall of Science, University of California, Berkeley, California 94720. Materials available from Rand McNally and Company, Customer Service Department, P. O. Box 7600, Chicago, Illinois 60680.